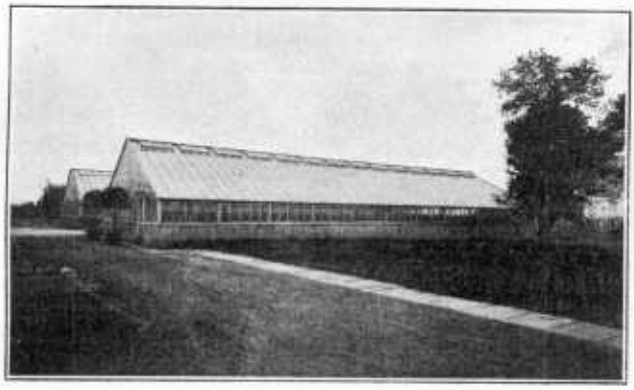
FUMIGATION OF ORNAMENTAL GREENHOUSE PLANTS WITH HYDROCYANIC-ACID GAS

E. R. SASSCER
Collaborator
and
A. D. BORDEN
Scientific Assistant



FARMERS' BULLETIN 880
UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. October, 1917

BY THE CAREFUL use of hydrocyanic-acid gas in accordance with the directions given in this bulletin practically all insects infesting the foliage of ornamental plants in greenhouses may be controlled, and more cheaply and effectively than by any other means.

In fumigating a house containing a large variety of plants, using the correct dosage and under proper conditions, the tender growth of some plants may be injured. This injury is not permanent, however, and such plants will show new vigorous growth in a short time. Moreover, the growth of many plants is stimulated by hydrocyanic-acid gas.

Chemicals required in fumigating with hydrocyanic-acid gas are sodium cyanid containing not less than 51 per cent cyanogen (or potassium cyanid containing not less than 38.4 per cent cyanogen), sulphuric acid 93 per cent pure, and water. Cyanid for fumigation purposes should be practically free from chlorin.

Fumigation should not be undertaken in daylight or when the temperature in the greenhouse is below 52° F. or above 70° F.

Cyanid is one of the most poisonous substances known. Care should be taken to observe the precautions stated on pages 11 and 12.

FUMIGATION OF ORNAMENTAL GREENHOUSE PLANTS WITH HYDROCYANIC-ACID GAS.

CONTENTS.

HYDROCYANIC-ACID GAS, if intelligently employed, is one of the cheapest and most efficient methods of controlling thrips, aphids, white flies, and various scale insects on plants grown under glass. This method of control, however, has not been adopted generally because of the deadly poisonous nature of the gas if inhaled, its disastrous effect on tender plants if improperly used, and the prevailing impression that fumigation is a cumbersome procedure requiring considerable skill on the part of the operator. It is true that much damage to the plants and injury to the operator may result from the *careless* use of hydrocyanic-acid gas, but it is an established fact also that this fumigant in competent hands is a safe, practical, and economical means of controlling virtually all insect pests found in greenhouses.

EQUIPMENT NECESSARY FOR FUMIGATION.

GENERATORS.

One-half-gallon or one-gallon glazed earthenware jars serve as satisfactory generators, although it is preferable that the bottoms of the jars be rounded inside, so that the cyanid will be covered with the acid and water, even with small doses, thus insuring the maximum generation of the gas.

CAUTION.—*Hydrocyanic-acid gas is colorless and is one of the most deadly poisonous gases known. It has an odor much like that of peach pits. In case of accidental inhalation of the gas, the person affected should be kept in the open air and required to walk to increase respiration.*

Crocks with straight sides are frequently sold with glazed earthenware tops. These tops or covers increase the cost of the generators and, furthermore, are useless for fumigation purposes. Therefore, when generators are ordered it should be indicated that tops are not desired.

MISCELLANEOUS REQUIREMENTS.

Correct scales or balances, reading in tenths of an ounce, are convenient for accurate work. An 8-ounce graduate is desirable for measuring the acid and water. To avoid splashing of the acid it should not be poured from a carboy or bottle into the graduate but should be transferred to a porcelain pitcher, from which it may be poured with safety. It is well to have on hand a supply of small bags in which to place the cyanid.

PREPARATION OF GREENHOUSE FOR FUMIGATION.

As a preliminary to fumigating the greenhouse it is essential that the exposed glass surface be examined carefully and all broken glass replaced. All cracks should be closed thoroughly. The ventilators—both side and top, where possible—should be so arranged that they can be opened from the outside of the greenhouse upon the completion of the exposure. This can be accomplished by disconnecting the "machine," or gear, of the top ventilators and attaching to the central ventilator shaft (see figs. 1 and 4) an arm (*a* or *b*) which can be controlled by a cord or wire which extends through the side of the greenhouse. The gears on the side ventilators may be disconnected so that the sash may be opened from the outside. If only one ventilator can be opened, it is preferable that it be the one on the roof of the greenhouse.

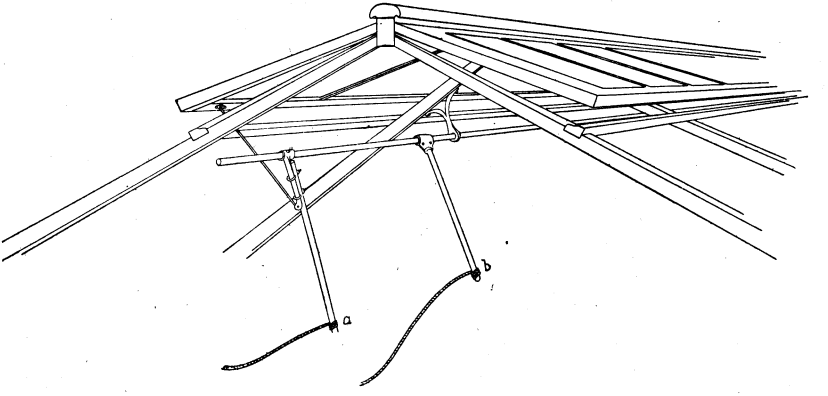


FIG. 1.—Methods of attaching rod and cord (*a*, *b*) to ventilator shaft of greenhouse so that the ventilators can be opened from the outside after fumigation.

METHOD OF COMPUTING THE CUBICAL CONTENTS OF EVEN AND THREE-QUARTER SPAN GREENHOUSES.

It is essential in every instance that the cubical contents of the greenhouse to be fumigated be determined accurately, and the following is a simple method of arriving at these figures: To facilitate matters a diagram indicating the necessary dimensions of the greenhouse should be made. (See figs. 2 and 3.)

To secure the cubical contents of the even-span greenhouse (fig. 2), compute the number of square feet in the rectangle a and in the right-angle triangles b and c and multiply the sum of the three by the length of the greenhouse. For example, $a=5\times20=100$ square feet; $b=5\times10\div2=25$ square feet;[1] and $c=5\times10\div2=25$ square feet. $a+b+c=150$ square feet. 150 square feet $\times$ 100 feet (length of house) $=15{,}000$ cubic feet, cubical contents of the greenhouse.

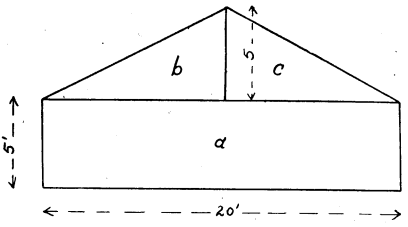


FIG. 2.—Diagram showing method of computing cubical contents of even-span greenhouse.

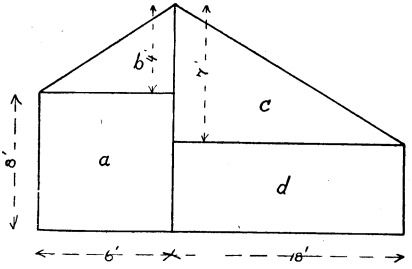


FIG. 3.—Diagram showing method of computing cubical contents of three-quarter-span greenhouse.

To secure the cubical contents of the three-quarter-span greenhouse (fig. 3), multiply the sum of the rectangles a and d and right-angle triangles b and c by the length. For example $a=6\times8=48$ square feet; $d=18\times5=90$ square feet; $b=6\times4\div2=12$ square feet; and $c=18\times7\div2=63$ square feet. $a+d+b+c=213$ square feet. 213 square feet $\times$ 100 feet (length of house) $=21{,}300$ cubic feet, cubical contents of greenhouse.

In estimating the cubical contents of a greenhouse it is not necessary to make allowances for the space occupied by the benches, pots, etc.

TIME FOR FUMIGATION.

Fumigation should be conducted not earlier than one hour after sunset and should not be attempted when the wind is high. It is undesirable to fumigate during extremely cold nights, when the thermometer is registering near zero, owing to the necessity of ven-

[1] To calculate the area of a right-angle triangle, multiply the base by the perpendicular and divide the product by two.

tilating the greenhouse upon the completion of an exposure. It is inadvisable to fumigate on hot, humid nights, when the temperature in the greenhouse can not be lowered readily to the desired limit. The best temperature for fumigation is between 55° and 68° F.

The interval between fumigations naturally should be governed by the reappearance of the insect under control. With small dosages, which are imperative when fumigating a greenhouse containing an assortment of plants, it is possible to kill only the larvæ of scale insects, the adults and first larva stages of the greenhouse white fly, the adults of the Florida fern caterpillar, greenhouse leaf-tyer, and loopers, and a certain percentage of aphids. The eggs and pupæ of most greenhouse insects offer considerable resistance to hydrocyanic-acid gas, and, furthermore, the overlapping of broods necessitates several fumigations at short intervals. It has been proved repeatedly that three or four fumigations at short intervals will give practical control.

CHEMICALS REQUIRED FOR FUMIGATION.

The chemicals required in fumigating with hydrocyanic-acid gas are sodium cyanid (NaCN) or potassium cyanid (KCN), sulphuric acid (H_2SO_4), and water (H_2O). Potassium cyanid has been superseded recently by sodium cyanid in the generation of this gas, and the former is rarely used nowadays in fumigation. Sodium cyanid for fumigation purposes should be practically free from chlorin and should contain not less than 51 per cent of cyanogen. It may be purchased either in lumps or in the shape of an egg, each "egg" weighing approximately 1 ounce. The latter is easily handled and the necessity of weighing each charge is obviated, provided, of course, the dosage is in ounces. For example, if the greenhouse requires 10 ounces of cyanid, 10 "eggs" are used. In small dosages, however, where the cyanid is measured in grams, it is necessary to use small lumps or break up the "eggs."

Cyanid is one of the most poisonous substances known and should be stored in air-tight cans, plainly labeled, and kept out of reach of those unacquainted with its poisonous nature.

Commercial sulphuric acid (about 1.84 sp. gr. or 66° Baumé) that is approximately 93 per cent pure is commonly used and gives very satisfactory results. The acid should be kept in a glass receptacle, properly labeled, and tightly corked with a glass stopper.

DETERMINING THE AMOUNT OF CYANID TO BE USED.

Satisfactory results are obtained only where it is possible to overcome the resisting power of the insects without overcoming the resisting power of the plant. Under favorable conditions greenhouses

that do not contain roses, rose geraniums, asparagus ferns, lemon verbenas, snapdragons, wandering Jew, or sweet peas can be fumigated with safety with an initial dosage of one-half ounce of sodium cyanid (NaCN) per 1,000 cubic feet. *In case there is any doubt as to the amount of gas a plant will stand without injury, it is preferable that the initial dosage be not over one-fourth ounce of sodium cyanid per 1,000 cubic feet* and increased with subsequent fumigations until the fatal point for the pest to be controlled is reached, it being borne in mind that in some instances it is not possible to effect an absolute control of all stages of some insects with one fumigation without injury to foliage or growing parts of certain plants. For example, the greenhouse white fly can be eradicated with three successive fumigations at intervals of seven to nine days, using one-half ounce of sodium cyanid (NaCN) per 1,000 cubic feet, in houses containing such susceptible plants as coleus, ageratum, heliotrope, fuchsia, etc., with no injury to the foliage. Moreover, such resistant pests as scale insects can be eliminated entirely by killing the immature stages with a small dosage repeated at frequent intervals.

To determine the total amount of cyanid to be used, ascertain from Table II on page 13 the plants in your greenhouse which are most easily injured by the gas fumes and note the amount of cyanid which was used per 1,000 cubic feet with little or no injury to the plants. Then multiply the number of thousand cubic feet contained in the greenhouse by the amount of cyanid to be used per 1,000 cubic feet. For example, if one-half ounce of cyanid is to be used per 1,000 cubic feet, and the greenhouse contains 15,000 cubic feet, the total amount of cyanid necessary would be $7\frac{1}{2}$ ounces.

In case there is any doubt as to the amount of gas the plant can stand without injury, the initial dosage, as previously stated, should not exceed one-fourth ounce per 1,000 cubic feet.

Table I gives the amount of sodium cyanid per 1,000 cubic feet needed to destroy the insect pests most commonly found in greenhouses. *Before fumigation is begun, however, Table II should be consulted for information as to the maximum dosage the particular plants can stand without injury. If this dosage is less than that indicated in Table I, complete control, of course, should not be attempted with one fumigation*

TABLE I.—*Amounts of cyanid and number of fumigations sufficient to destroy various greenhouse pests.*

Insects.	Ounces per 1,000 cubic feet.	Number of fumigations required.	Interval between fumigations.
			Days.
Aphids[1]	½	1	
Azalea lacewing	½	1	
Thrips	½	2	10.
Greenhouse white fly	½	3	7 to 9.
Long scale	¾	1	
Greenhouse Orthezia[2]	¾	2	21 to 28.
Palm mealybug[2]	2½	1	
Palm aphis	2½	1	
Long-tailed mealybug[2]	2½	2	Do.
Florida red scale	2½	2	Do.
Thread scale	2½	2	Do.
Aspidistra scale	2½	2	Do.
Soft brown scale	2½	2	Do.
Hemispherical scale	2½	2	Do.
Tessellated scale	2½	2	Do.
Florida fern caterpillar	5	1	
Citrus mealybug[2]	5	2	Do.

[1] For the most part aphids can be controlled with one-half ounce of sodium cyanid per 1,000 cubic feet, although there are a few species which are quite resistant to this gas and not so readily killed.

[2] The greenhouse Orthezia and mealybugs around the roots of plants are very difficult to kill, and this dosage is recommended only for those occurring above the soil.

CHEMICAL FORMULA TO BE EMPLOYED.

The chemicals [1] should be mixed in the following proportions: For each ounce of sodium cyanid use 1½ fluid ounces of sulphuric acid and 2 fluid ounces of water.

MIXING THE CHEMICALS.

After the generators have been distributed throughout the greenhouse, and before the chemicals have been mixed, the cyanid should be weighed accurately and the proper amount for each generator placed in a paper bag near the generator. The chemicals should be mixed invariably in the following manner: First, measure and place in each generator the amount of water required; second, measure and place in each generator the amount of sulphuric acid required; third, drop the cyanid into the diluted warm acid in each generator, immediately leave the greenhouse, and post a danger sign on the closed door. The cyanid should be dropped gently from the bag, not thrown, into the generators, and the operator should begin at the generator farthest from the door and work toward the door. In case there are two rows of generators the cyanid should be dropped simultaneously by two operators. As little time as possible should elapse between the addition of the acid and the addition of the cyanid, as the heat which is liberated by the mixing of the acid and water assists in the generation of the gas.

[1] If potassium cyanid is used in place of sodium cyanid, the formula should be as follows: For each ounce of 98 to 99 per cent potassium cyanid containing 38.4 per cent cyanogen use 1 ounce of sulphuric acid and 3 ounces of water. The yield from 1 ounce of high-grade sodium cyanid is equivalent to the yield from 1⅓ ounces of high-grade potassium cyanid.

The residue left in the generators after fumigation should be buried or poured into a sink and the generator washed before being stored for future operations.

NUMBER OF GENERATORS TO BE EMPLOYED.

The number of generators to be employed will depend largely upon the size of the greenhouse, and they should be so arranged that the gas will be distributed uniformly throughout the inclosure. To secure this advantage a number of generators should be used rather than one large generator. Generators should be spaced from 20 to 25 feet apart (see fig. 4), and in case of a light wind a few extra generators should be placed on the windward side of the greenhouse. An ounce to each jar is as small a dose as is practicable, unless the generators are well rounded inside at the base or well tilted.

EXPOSURES.

Short exposures with a greater strength of gas are more satisfactory than a weaker strength of gas overnight. In fact, better results will be gained if the exposures do not exceed one to two hours. An exposure of one hour is satisfactory in most instances. Short exposures also have the additional advantage of permitting the greenhouse to become thoroughly aired previous to the rising of the sun.

VENTILATION AFTER FUMIGATION.

If there is a light wind, a ventilation of 10 to 15 minutes, using side and top ventilation, will be sufficient and will not lower the greenhouse temperature to a dangerous point unless it is close to zero weather outside. If it is a still evening and the outside temperature is not below 32° F., a 20 to 30 minute ventilation will be satisfactory.

In case it is necessary to enter the greenhouse shortly after ventilation to determine the temperature, the person entering should not remain any longer than is necessary.

EFFECTS OF WEATHER AND OTHER CONDITIONS ON FUMIGATION.

TEMPERATURE.

It is not advisable to fumigate if the temperature in the greenhouse exceeds 70° F. or if the temperature is less than 52° F.

LIGHT.

Light unquestionably affects fumigation. It has been known for a long time that it is very unsafe to fumigate when the sun is high. Furthermore, some injury may result to plants which have been subjected to fumes if, on the following day, the sun is very bright.

MOISTURE.

Hydrocyanic-acid gas is readily soluble in water, and as a result the presence of excessive moisture in greenhouses decreases the

effectiveness of the gas and consequently lessens the possibility of injury to the plants by burning. It is obvious, therefore, that in order to increase the effectiveness of the fumigation the plants should be syringed not less than four or five hours prior to the liberation of the gas, to avoid undue absorption of the gas by the water on the benches and walks.

HUMIDITY.

A relatively high humidity (98 to 100), with temperature varying from 70° to 75° F., greatly increases the amount of injury to the foliage of the plants, whereas plants in the presence of the same high humidity (98 to 100), with a temperature of 60° to 65° F., will exhibit little if any injury.

ADVISABILITY OF A FUMIGATION BOX.

A fumigation box is desirable for two reasons, namely, for testing the amount of gas plants can stand without injury, and for ridding a limited number of potted plants of insects, and thus avoiding costly and laborious hand scrubbing of such plants. The size of the box will depend on the use to which it is to be put. A box with a capacity of 200 cubic feet can be used advantageously for nursery stock, palms, etc.

Plants to be fumigated in a box in the daytime should remain in the box with the door closed at least one hour before the gas is generated and should be shaded from the bright sunlight for at least two hours after the completion of the exposure.

HOW GREENHOUSES BECOME INFESTED WITH INSECTS.

Doubtless many greenhouses become infested with insects through the agency of plants commonly referred to as "boarders." The practice of turning over home-grown plants to a florist to care for during the absence of the owner on a vacation is prevalent over the entire country, and often results in establishing pests not hitherto known to occur on the florist's premises. If the trade requires such a practice, plants of this character should be cleaned thoroughly of insect pests before being placed with the regular stock of the greenhouse.

Insect infestations in greenhouses have been traced to the following sources: Infested plants brought in from coldframes or propagating beds which have not received proper attention; cuttings, plants, and buds received from other establishments; and imported foreign or domestic stock. Adults of the greenhouse white fly, grasshoppers, beetles, aphids, etc., may enter through open ventilators from other greenhouses or gardens; cutworms, wireworms, white grubs, etc., may be brought into the greenhouse with the soil; and roaches, ants, sow-

bugs, millipedes, etc., are sometimes brought in with packages, or they may crawl into the greenhouse through small openings.

COST OF HYDROCYANIC-ACID GAS FUMIGATION.

The economy in the use of hydrocyanic-acid gas as a means of controlling aphids, white flies, thrips, and the common greenhouse scale insects is apparent from the following figures, which are based on current manufacturers' prices:

For the most part, aphids can be controlled with a single fumigation at the rate of one-half ounce per 1,000 cubic feet at a cost of approximately 1 cent per 1,000 cubic feet. Tobacco fumigation with standard tobacco paper costs from 1½ to 3 cents per 1,000 cubic feet, and to secure a satisfactory control the operation must be repeated several times. Standard nicotine soap solution costs from 1 to 3 cents per gallon, and 4 gallons are required to cover plants which would occupy 1,000 cubic feet of space.

The greenhouse white fly can be controlled with three successive fumigations at the rate of one-half ounce of sodium cyanid per 1,000 cubic feet, with a total cost of 3 cents per 1,000 cubic feet for a complete control. Standard insecticides cost about 6 cents per 1,000 cubic feet for a single application, and fully four applications are required for a satisfactory control.

Thrips can be controlled on such plants as azaleas, lilies, and ferns with a single fumigation at the rate of one-half ounce of sodium cyanid per 1,000 cubic feet at a cost of 1 cent per 1,000 cubic feet. A single application of nicotine soap solution costs fully five times as much as the gas treatment and still gives only a partial control.

The common scale insects of greenhouses (excepting mealybugs) can be controlled by fumigating the infested plants at the rate of three-fourths ounce of sodium cyanid per 1,000 cubic feet at a cost of 1½ cents per 1,000 cubic feet. The standard proprietary insecticides commonly recommended for scale insects cost approximately 4 cents per gallon, with an average cost of 16 cents per 1,000 cubic feet for each treatment. A 5 per cent homemade kerosene emulsion costs approximately one-half cent more per 1,000 cubic feet than does the gassing method, and gives very indifferent results.

The foregoing figures do not take into consideration the cost of labor. The time required for fumigation, however, will not exceed the time required for the mixing and application of the sprays.

PRECAUTIONS.

Do not *guess* the amount of chemicals to be employed or the cubic contents of the house.

Do not fumigate plants in a greenhouse in daylight. (For box fumigation in daytime, see page 10.)

Do not fumigate when the temperature in the greenhouse is below 52° or above 70° F.

Do not leave the chemicals within reach of those unacquainted with their poisonous nature. Always have them properly labeled.

Do not handle the chemicals any more than is absolutely necessary. It is well to have a pair of old gloves for this, and to use them for no other purpose. Always wash the hands thoroughly after handling the chemicals whether gloves have been used or not.

Do not allow the acid to splash or drop on the clothing or skin.

Do not stay in the greenhouse any longer than is necessary to place the cyanid in the jars, and *never* enter a greenhouse charged with the gas until it has been thoroughly aired.

Do not fail to post danger signs at all entrances before setting off the charge, and to see that the greenhouse is closed tightly.

Do not attempt to fumigate without adjusting the ventilators so that they can be operated from the outside.

Do not attempt to fumigate a large greenhouse alone.

Do not fumigate a greenhouse adjoining a dwelling without notifying the occupants before fumigation.

Do not pour the water on the acid; pour the acid on the water.

Do not become negligent in any of the precautions; to do so may cause serious results.

GUIDE TO GREENHOUSE FUMIGATION.

Table II is offered as a guide to those desiring to employ hydrocyanic-acid gas for controlling greenhouse pests. As indicated in this table, certain insects and plants are more resistant to hydrocyanic-acid gas than are others, and this fact should be borne in mind when a greenhouse containing a miscellaneous collection of plants is to be fumigated.

TABLE II.—*Results of fumigation with hydrocyanic-acid gas in greenhouses and boxes.*

[Plants with an * were fumigated in a box.]

Name of plant.	Rate in ounces per 1,000 cubic feet.		Exposure in hours.	Greenhouse temperature.	Infestation.	Results of treatment.	
	Sodium cyanid.	Potassium cyanid.				On plants.	On insects.
				°F.			
Abutilon sp	½	.....	1	58	Greenhouse white fly.	No burning	All stages except eggs and late pupæ killed.
Do	¾	.....	1	68	do	do	Do.
Acalypha sp	¾	.....	1	60		do	
Achyranthes sp	¾	.....	1	60		do	
Ageratum sp	½	.....	1	58	Greenhouse white fly.	do	Do.
Do	5	.....	1	52		Tender tips burned.	
Air plant	¾	.....	1	68	Aphids	No burning	100 per cent killed.
Allamanda hendersoni	½	.....	1	60		do	
Alpinia sanderae	½	.....	1	62		do	
Alternanthera sp	½	.....	1	60		do	
*Do	.....	10	1	73		do	
Althea sp	½	.....	1	60	Aphids	do	Do.
Amaranthus sp	¾	.....	1	55		do	
Amaryllis sp	¾	.....	1	68		do	
Anthericum comosum	½	.....	1	60	Long scale	do	80 per cent killed
Do	¾	.....	1	60	do	do	100 per cent killed.
Anthurium sp	½	.....	1	60		do	
Ardissia sp	½	.....	1	62		do	
Araucaria excelsa	½	.....	1	66		do	
Aristolochia sipho	.....	5	¾	66		do	
Artemisia sp	.....	1½	1	73		Slight burning	
Artillery plant	½	.....	1	70		No burning	
Asparagus plumosus	½	.....	1	66		Tips burned	
Asparagus sprengeri	½	.....	1	60		Tender tips burned.	
Aspidistra lurida	2½	.....	1	62	Florida red scale	No burning	Do.
Aster	½	.....	1	62		do	
Aucuba japonica	¾	.....	1	68		do	
Azalea sp	5	.....	1	50	Greenhouse thrips.	do	Do.
Do	½	.....	1	60	do	do	Do.
Do	½	.....	1	60	Azalea lacewing	do	Do.
Do	¾	.....	1	60	Azalea Eriococcus.	do	50 per cent killed.
Do	.....	7½	1	.....		Slight burning	
Begonia sp	½	.....	1	60	Greenhouse Orthezia.	No burning	70 per cent killed.
Do	5	.....	1	52		do	
Berberis renderiana	½	.....	1	62		do	
Bougainvillea	¾	.....	1	56		do	
Do	5	.....	1	52		Foliage burned	
Buxus sp	.....	7½	1	.....		No burning	
Calendula	½	.....	1	60		do	
Caladium	5	.....	1	52		do	
Camellia japonica	5	.....	1	52	Citrus mealybug.	do	100 per cent killed.
*Do	10	.....	1	60		New growth burned.	
Canna	½	.....	1	64		No burning	
Carnation	1	.....	1	54	Greenhouse thrips.	do	Do.
*Do	5	.....	1	73		Tender foliage burned.	
Centaurea	½	.....	1	60	Onion thrips	No burning	95 per cent killed.
Cereus (night-blooming)	2½	.....	1	63		do	
Chrysanthemums:							
Single-stem var	½	.....	1	62	Aphids	do	100 per cent killed.
Do	¾	.....	1	68	do	do	Do.
Pompon var	½	.....	1	62	do	do	Do.
Do	1	.....	1	67	do	do	Do.
Cigar plant	¾	.....	1	68	do	do	Do.
Cineraria	¾	.....	1	60	do	do	Do.
Clerodendron	.....	5	¾	66		do	

TABLE II.—*Results of fumigation with hydrocyanic-acid gas in greenhouses and boxes*—Continued.

[Plants with an * were fumigated in a box.]

Name of plant.	Rate in ounces per 1,000 cubic feet.		Exposure in hours.	Greenhouse temperature.	Infestation.	Results of treatment.	
	Sodium cyanid.	Potassium cyanid.				On plants.	On insects.
				°F.			
Cockscomb	½	.....	1	64	.....	No burning	
Coleus	¾	.....	1	66	Greenhouse Orthezia.	.....do	100 per cent killed.
Columbine	5	.....	1	59	.....	.....do	
Coreopsis	½	.....	1	62	.....	.....do	
Cosmos	½	.....	1	60	.....	Tips burned	
Croton	¾	.....	1	56	Long scale	No burning	Do.
Do	5	.....	1	52	Immature citrus mealybug.	.....do	Do.
*Do	10	.....	¾	68	Long scale	.....do	Do.
Cycas circinalis	2½	.....	1	63	Florida red scale	.....do	Do.
Cyclamen	¾	.....	1	68	.....	.....do	
*Do	10	.....	1	60	.....	Flowers killed	
Daffodil	¾	.....	1	55	.....	No burning	
Deutzia gracilis	.....	1½	½	.....	Aphids	.....do	Do.
Digitalis	½	.....	1	62	.....	.....do	
Dioscorea pentaphylla	½	.....	1	64	.....	.....do	
Dracaena knerki	2½	.....	1	63	Long-tailed mealybug.	.....do	Do.
Dracaena indivisa	.....	5	¾	52	.....	.....do	
Dusty miller	½	.....	1	60	.....	.....do	
Erica sp	½	.....	1	64	.....	.....do	
Eupatorium sp	¾	.....	1	60	.....	.....do	
Euphorbia sp	½	.....	1	60	.....	.....do	
Euonymus sp	½	.....	1	60	.....	.....do	
Ferns:							
Adiantum cuneatum	5	.....	1	59	.....	.....do	
Do	5	.....	¾	62	Larvæ of Fla. fern caterpillar.	.....do	Do.
*Do	7½	.....	¾	68	.....do	.....do	Do.
*Do	10	.....	¾	68	.....do	New growth burned.	Do.
Adiantum croweanum	5	.....	1	59	.....	No burning	
Adiantum gracilium	½	.....	1	57	Fern aphid	.....do	Do.
Adiantum trapeziforme.	½	.....	1	57	.....do	.....do	Do.
Adiantum cardiocheleana.	2½	.....	1	63	.....	.....do	
Aspidium tsus-sinense	2½	.....	1	59	.....	.....do	
Asplenium nidus-avis	¾	.....	1	68	.....	.....do	
Cyrtomium rochfordianum.	2½	.....	1	59	.....	.....do	
Cyrtomium falcatum	¾	.....	1	60	.....	.....do	
Lastraea chrysoloba	¾	.....	1	68	.....	.....do	
Nephrolepis bostoniensis.	2½	.....	1	63	Aspidistra scale	.....do	Do.
*Do	5	.....	¾	62	Larvæ of Fla. fern caterpillar.	.....do	Do.
*Do	7½	.....	¾	68	.....do	.....do	Do.
*Do	10	.....	1	68	.....do	New growth burned.	Do.
*Do	.....	5	½	76	Aspidistra scale	No burning	All stages except eggs killed.
Nephrolepis scottii	2½	.....	1	59	.....	.....do	
Nephrolepis whitmanii.	2½	.....	1	59	.....	.....do	
Do	5	.....	¾	66	Larvæ of Fla. fern caterpillar.	.....do	100 per cent killed.
Polystichum setosum.	¾	.....	1	60	.....	.....do	
Pteris wilsoni	2½	.....	1	63	.....	.....do	
Pteris wimsetti	2½	.....	1	63	.....	.....do	
Ficus elastica	2½	.....	1	59	Florida red scale	.....do	Do.
Ficus pandurata	2½	.....	1	63	Long-tailed mealybug.	.....do	Do.
Ficus utilis	2½	.....	1	63	.....	.....do	
Forgetmenot	½	.....	1	56	.....	.....do	
Do	5	.....	1	52	.....	Tips burned	
Forsythia viridissima	.....	1⅛	½	.....	Aphids	No burning	Do.
Freesia	¾	.....	1	60	.....	.....do	
Fuchsia	½	.....	1	60	Aphids	.....do	Do.

TABLE II.—*Results of fumigation with hydrocyanic-acid gas in greenhouses and boxes*—Continued.

[Plants with an * were fumigated in a box.]

Name of plant.	Rate in ounces per 1,000 cubic feet.		Exposure in hours.	Greenhouse temperature.	Infestation.	Results of treatment.	
	Sodium cyanid.	Potassium cyanid.				On plants.	On insects.
				°F.			
Fuchsia	½	.....	1	60	Greenhouse white fly.	No burning	All stages except eggs and late pupæ killed.
Do	5	.....	1	58	.....	Tips burned	
Gaillardia sp	½	.....	1	62	.....	No burning	
Gardenia	5	.....	1	60	.....	do	
Do	.....	7½	1	.....	.....	Slight burning	
Genista	¾	.....	1	55	Red spider	No burning	No killing.
Do	5	.....	1	52	do	Flowers and new growth burned.	100 per cent killed.
Geraniums:							
Bedding	½	.....	1	60	Greenhouse white fly.	No burning	All stages except eggs and late pupæ killed.
Do	5	.....	1	60	.....	New growth burned.	
Peppermint	¾	.....	1	68	.....	No burning	
Rose	½	.....	1	64	.....	New growth burned.	
Gladiolus	¾	.....	1	55	.....	No burning	
Heather (Scotch)	¾	.....	1	68	.....	do	
Do	.....	5	¾	52	.....	Slight burning	
Heliotrope	¾	.....	1	60	.....	No burning	
Do	5	.....	1	58	.....	Tips burned	
Hibiscus sp	¾	.....	1	55	.....	No burning	
Hyacinth (Roman)	2	.....	1	56	.....	do	
Hyacinth (water)	¾	.....	1	55	.....	do	
Hydrangea	¾	.....	1	60	.....	do	
Impatiens sultani	¾	.....	1	68	Aphids	do	100 per cent killed.
Ipomoea grandiflora	¾	.....	1	60	.....	Open flowers burned.	
Ivy (English)	5	.....	1	48	Fla. red scale	No burning	96 per cent killed.
Ivy (German)	¾	.....	1	58	Spanish red scale.	do	100 per cent killed.
Iris (Spanish)	½	.....	1	64	.....	do	
Do	.....	5	¾	66	.....	Tips burned	
Jerusalem cherry	½	.....	1	60	Aphids	No burning	Do.
Lantana	½	.....	1	60	Orthezia	do	90 per cent killed.
Do	¾	.....	1	56	.....	do	
Laurus nobilis	5	.....	1	54	Soft brown scale.	No burning	95 per cent killed.
					Laurel scale		98 per cent killed.
					Long-tailed mealybug.		100 per cent killed.
Do	.....	7½	1	.....	Soft brown scale.	No burning	90 per cent killed.
Lillies:							
Calla	½	.....	1	64	.....	do	
Do	.....	5	¾	65	.....	do	
Lilium formosum	½	.....	1	60	Aphids	do	100 per cent killed.
Do	¾	.....	1	60	.....	do	
Lilium multiflorum	½	.....	1	60	Aphids	do	Do.
Do	¾	.....	1	60	.....	do	
Lilium speciosum rubrum.	½	.....	1	58	Aphids	do	No killing.
Lobelia	5	.....	1	59	.....	Tips burned	
Marguerite	½	.....	1	70	Aphids	No burning	100 per cent killed.
Do	½	.....	1	60	Immature hemispherical scale.	do	95 per cent killed.
Do	¾	.....	1	68	.....	do	
Marigold (French)	¾	.....	1	64	.....	do	
Mignonette	½	.....	1	60	.....	do	
Do	5	.....	1	52	.....	Tips burned	
Mimulus moschatus	¾	.....	1	56	.....	No burning	
Narcissus poeticus	¾	.....	1	55	.....	do	

TABLE II.—*Results of fumigation with hydrocyanic-acid gas in greenhouses and boxes*—Continued.

[Plants with an * were fumigated in a box.]

Name of plant.	Rate in ounces per 1,000 cubic feet.		Exposure in hours.	Greenhouse temperature.	Infestation.	Results of treatment.	
	Sodium cyanid.	Potassium cyanid.				On plants.	On insects.
				°F.			
Narcissus barri	¾	.....	1	55	.....	No burning	
Nasturtium	⅔	.....	1	55	.....	do	
Nigella sp	½	.....	1	62	Aphids	do	100 per cent killed.
Nymphaea sp	2½	.....	1	63	.....	do	
Orchids:							
Angraecum eburneum.[1]	½	.....	1	60	.....	do	
*Do.[1]	5	.....	1	62	Diaspis sp	Slight burning	Do.
Brassea verrucosa.[1]	½	.....	1	57	.....	No burning	
Calanthe (hybrid)[1]	½	.....	1	58	.....	do	
Cattleya mossiae[1]	½	.....	1	60	.....	do	
Cattleya trianae[1]	½	.....	1	57	Thrips	do	All stages except eggs killed.
Cattleya trianae[2]	20	.....	¾	70	.....	do	
Cattelya sp[2]	.....	20	½	.....	.....	do	
Do	.....	21	1	.....	.....	do	
Do	.....	42	½	.....	.....	Slight burning, plant recovered.	
Chysis aurea	½	.....	1	57	.....	No burning	
*Coelia baueri	5	.....	1	62	.....	do	
Coelogyne cristata	⅕	.....	1	57	.....	Few old leaves burned.	
*Coelogyne flaccida	5	.....	1	62	Chaff scale	No burning	100 per cent killed.
Coelogyne massangeana.	½	.....	1	60	.....	do	
Coelogyne speciosa	½	.....	1	57	.....	do	
Cymbidium pendulum.	½	.....	1	57	.....	do	
Cypripedium callosum.	½	.....	1	60	Thrips	do	All stages except eggs killed.
Cypripedium calypso	½	.....	1	60	do	do	Do.
Cypripedium spicerianum.	½	.....	1	60	do	do	Do.
Cypripedium venustum.	½	.....	1	57	do	do	Do.
*Cypripedium sp	5	.....	1	62	.....	do	
Dendrobium ainsworthi.	½	.....	1	57	.....	do	
Dendrobium aggregatum.	½	.....	1	57	.....	do	
*Dendrobium fimbriatum.	5	.....	1	62	Lepidosaphes sp.	do	100 per cent killed.
Dendrobium grandiflorum.	½	.....	1	57	.....	do	
Dendrobium nobile	½	.....	1	60	.....	do	
Dendrobium parishii	½	.....	1	57	.....	do	
Epidendrum prismatocarpum.	½	.....	1	57	.....	do	
Laelia anceps	½	.....	1	57	.....	do	
Laelia acuminata	½	.....	1	57	.....	do	
Laelia superbiens	½	.....	1	60	.....	do	
Maxillaria graminifolia.	½	.....	1	57	.....	do	
Oncidium embratium	½	.....	1	60	.....	do	
Oncidium papiliomajus.	½	.....	1	60	.....	do	
Oncidium sphacelatum.	½	.....	1	57	.....	do	
Oncidium splendidum	½	.....	1	57	.....	do	
Odontoglossum sp	½	.....	1	58	.....	do	
Phalaenopsis schilleriana.	½	.....	1	60	.....	do	
Pholidota imbricata	½	.....	1	57	.....	do	

[1] Orchids in growing condition, practically all having new growth, flower bud, or blossom.
[2] Imported orchids without new growth.

TABLE II.—*Results of fumigation with hydrocyanic-acid gas in greenhouses and boxes*—Continued.

[Plants with an * were fumigated in a box.]

Name of plant.	Rate in ounces per 1,000 cubic feet.		Exposure in hours.	Greenhouse temperature.	Infestation.	Results of treatment.	
	Sodium cyanid.	Potassium cyanid.				On plants.	On insects.
Orchids—Continued.				°F.			
Schomburgkia tibicinis.	½	.....	1	57	.....	No burning.....	
Schomburgkia undulata.	5	.....	1	62	.....	.....do.....	
Sobralia macrantha...	½	.....	1	58	.....	.....do.....	
Thunia marshalliana.	½	.....	1	58	.....	.....do.....	
Vanda caerulea.....	½	.....	1	58	.....	.....do.....	
Palms:							
Areca lutescens.....	2½	.....	1	63	Palm mealybug, tessellated scale.	.....do.....	100 per cent killed.
*Do.....	.....	10	1	65	Tessellated scale.	.....do.....	Do.
Cocos plumosa.....	2½	.....	1	59	Tessellated scale, palm mealybug.	.....do.....	Do.
Kentia belmoreana...	2½	.....	1	59	Palm aphid, palm mealybug, thread scale, Florida red scale.	Slight burning of some new growth.	Do.
*Kentia belmoreana..	.....	5	½	.....	Palm mealybug, palm aphid.	No burning.....	Do.
Kentia fosteriana.....	2½	.....	1	59	Palm aphid, Florida red scale, thread scale.	Slight burning of some new growth.	Do.
Latania borbonica....	2½	.....	1	63	Thread scale....	No burning.....	Do.
Phoenix roebeleni....	2½	.....	1	63	Thread scale, tessellated scale.	.....do.....	Do.
*Phoenix sp.....	.....	10	1	73	.....	.....do.....	
Rhapis flabilliformis..	2½	.....	1	59	Palm mealybug, tessellated scale.	.....do.....	Do.
Pandanus graminifolius.	¾	.....	1	68	.....	.....do.....	
Pandanus veitchi.....	¾	.....	1	68	.....	.....do.....	
*Do.....	.....	10	1	73	Florida red scale	.....do.....	Do.
Pansy.....	½	.....	1	62	Aphids.....	.....do.....	Do.
Do.....	5	.....	1	52	.....	.....do.....	
Pelargonium sp.....	¾	.....	1	68	Aphids.....	.....do.....	75 per cent killed.
Pentstemon sp.....	.....	5	¾	52	.....	.....do.....	
Do.....	.....	7½	1	.....	.....	Slight burning..	
Petunia.....	½	.....	1	60	.....	No burning.....	
Poinsettia.....	½	.....	1	62	.....	.....do.....	
Poppy (Shirley).....	½	.....	1	60	.....	.....do.....	
Poppy (water).....	2½	.....	1	60	.....	.....do.....	
Primula (Chinese).....	¾	.....	1	56	.....	.....do.....	
Do.....	.....	5	¾	66	.....	.....do.....	
Primula malacoides....	¾	.....	1	55	.....	.....do.....	
Primula obconica.....	¾	.....	1	55	.....	.....do.....	
Rhododendron.....	.....	5	¾	66	.....	.....do.....	
Rosemary.....	½	.....	1	64	.....	.....do.....	
Roses (seven commercial varieties).	⅜	.....	1	49	.....	.....do.....	
Do.....	½	.....	1	56	.....	New growth burned.	
Sansevieria.....	2½	.....	1	63	.....	No burning.....	
Scarlet sage.....	¾	.....	1	60	.....	.....do.....	
Schizanthus sp.....	¾	.....	1	56	.....	.....do.....	
Smilax.....	5	.....	1	48	.....	New growth burned.	
Snapdragon.....	½	.....	1	60	.....	New growth and floral spikes burned.	

TABLE II.—*Results of fumigation with hydrocyanic-acid gas in greenhouses and boxes*—Continued.

[Plants with an * were fumigated in a box.]

Name of plant.	Rate in ounces per 1,000 cubic feet.		Exposure in hours.	Greenhouse temperature.	Infestation.	Results of treatment.	
	Sodium cyanid.	Potassium cyanid.				On plants.	On insects.
				°F.			
Spiraea sp	¾	.....	1	60	.....	No burning	
Stephanotis floribunda	.....	5	¾	60	.....	do	
Stevia	½	.....	1	60	.....	do	
Stocks	½	.....	1	62	.....	do	
Swainsona sp	½	.....	1	60	.....	do	
Sweet peas	½	.....	1	60	Aphids	Tips and blossoms burned.	100 per cent killed.
Sweet William	½	.....	1	56	.....	No burning	
Thumbergia erecta	½	.....	1	64	.....	do	
Tulip	¾	.....	1	55	.....	do	
Umbrella plant	2½	.....	1	63	Red spider	do	Do.
Verbena (hardy)	¾	.....	1	60	.....	do	
Verbena (lemon)	½	.....	1	64	.....	New growth burned.	
Vinca major variegata	¾	.....	1	56	.....	No burning	
Do	.....	5	¾	66	.....	do	
Vinca rosea	¾	.....	1	60	.....	do	
Violet	5	.....	1	48	Aphids	do	Do.
Wandering Jew	½	.....	1	64	.....	Severe burning	

In order that there may be no confusion on the part of the reader as to the insects referred to in the tables by their common names, both their common and scientific names are listed herewith:

Greenhouse white fly.....*Trialeurodes vaporariorum* (Westw.).
Citrus mealybug.....*Pseudococcus citri* (Risso).
Long-tailed mealybug.....*Pseudococcus adonidum* (L.).
Palm or avocado mealybug.....*Pseudococcus nipae* (Mask.).
Greenhouse Orthezia.....*Orthezia insignis* (Dougl.).
Florida red scale.....*Chrysomphalus ficus* (Ashm.).
Long scale.....*Coccus elongatus* (Sign.).
Soft brown scale.....*Coccus hesperidum* (L.).
Palm aphis.....*Cerataphis lataniae* (Boisd.).
Hemispherical scale.....*Coccus hemispherica* (Targ.).
Florida fern caterpillar.....*Eriopus floridensis* (Guen.).
Aspidistra scale.....*Hemichionaspis aspidistrae* (Sign.).
Tessellated scale.....*Eucalymnatus tessellatus* (Sign.).
Azalea Eriococcus.....*Eriococcus azaleae* (Horv.).
Azalea lacewing.....*Stephanitis azaleae* (Horv.).
Greenhouse thrips.....*Heliothrips haemorrhoidalis* (Bouché).
Thread scale.....*Ischnaspis longirostris* (Sign.).
Chaff scale.....*Parlatoria proteus* (Curt.).
Spanish red scale.....*Chrysomphalus dictyospermi* (Morg.).

FIG. 4.—Greenhouse ready for fumigation.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO INSECTS INJURIOUS TO GREENHOUSE AND GARDEN PLANTS.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Verbena Bud-moth. (Department Bulletin 226.)
Violet Rove Beetle. (Department Bulletin 264.)
European Earwig and its Control. (Department Bulletin 566.)
Rose-chafer. (Entomology Circular 11.)
Florida Fern Caterpillar. (Entomology Bulletin 125.)
Abutilon Moth. (Entomology Bulletin 126.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Rose Aphis. (Department Bulletin 90.) Price, 5 cents.
Greenhouse White Fly. (Entomology Circular 57.) Price, 5 cents.
Common Red Spider. (Entomology Circular 104.) Price, 5 cents.
Rose Slugs. (Entomology Circular 105.) Price, 5 cents.
Larger Canna Leaf-roller. (Entomology Circular 145.) Price, 5 cents.
Greenhouse Thrips. (Entomology Circular 151.) Price, 5 cents.
Flour Paste as a Control for Red Spiders and as a Spreader for Contact Insecticides. (Entomology Circular 166.) Price, 5 cents.
Some Insects Injurious to Violet, Rose, and Other Ornamental Plants. (Entomology Bulletin 27, n. s.) Price, 10 cents.
Fall Army Worm and Variegated Cutworm. (Entomology Bulletin 29, n. s.) Price, 5 cents.
Rose Slug-caterpillar. (Entomology Bulletin 124.) Price, 5 cents.